How a specific technique supports Architectural representation

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ABSTRACT

How a specific technique supports architectural representation

Previously, architects transferred their ideas from their mind and intellect directly to the paper. Now, computers and advanced devices are instruments that have integrated themselves as a middle layer in this process. A subtle effect of this development is that along with the architect's ideas, the output is also dependent on the architect's understanding, comfort, and skill in the technological layer and instruments, which are not unlike a vehicle carrying the architects thoughts to the desired destination of the output. This essay analyzes the relationship between architectural drawings and the use of computers to create those drawings.

In the 2019 Spring Semester Option Studio, the students explored how drawings can be expressed and enhanced by Computer Numerical Control (CNC) technology. CNC machines operate along the X, Y, and Z axes. Because of this mechanism, drawing paths can only be implemented through a change in the code of the X,Y, and Z axis values. This restriction affects the development of architectural ideas. Users need to make the decision regarding how the code will be formed and read. There is another way of exploit computer using coding program Python and Processing. Two case studies from coding program demonstrate how certain drawings are not possible without the knowledge of the technological instruments that are able to make them. The last seminar class focused on the conversion of written text to 2D drawing. In the process, a black-and-white hatch and tone was used to create spatial depth and atmosphere. The purpose of this exercise was to acknowledge the potential and efficiency of expressing spatiality and other ideas in written text with simple black-and-white options.

1. Introduction

Throughout history, architects have devoted themselves to the study of design. They have employed tools and processes such as line and paper drawings, surface and volume examination, and combining spaces and inspiration for realizing their visions. Technically, an architect's primary purpose is to produce and illustrate ideas on paper. That is, an architect seeks to create the best imagination of a structure to be built, but the process of building of the structure itself is not the architect's expertise. Through their work, architects aim to explore and suggest 'something that a structure represents'; in other words, they concern themselves with a larger goal than simply a specific, physical structure. In this pursuit, architects challenge themselves to do justice to the art of reflecting their vision of a three dimensional space onto an ordinary, everyday two dimensional paper using schematics and drawings. Which architecture elements and ideas should be expressed in their drawings, how, and to what extent? All great architects have encountered these questions and choices. Computer-aided designing and ever-evolving technological tools are influencing this age-old question and shaping it in new ways in today's world and society. Previously, architects transferred their ideas from their mind and intellect directly to the paper. Now, computers and advanced devices are instruments that have integrated themselves as a middle layer in this process. A subtle effect of this development is that along with the architect's ideas, the output is also dependent on the architect's understanding, comfort, and skill in the technological layer and instruments, which are not unlike a vehicle carrying the architects thoughts to the desired destination of the output. This essay analyzes the relationship between architectural drawings and the use of computers to create those drawings.

2. CNC Drawing

2.1 CNC Drawing

In the 2019 Spring Semester Option Studio CRIMINAL BEHAVIOR: Ornamental Exuberance through Efficiency, instructor Martin Miller and the students explored how drawings can be expressed and enhanced by Computer Numerical Control (CNC) technology. We discussed and debated the effectiveness of computers and technology to extend conceptual objectives, such as digital fabrication, computer-specific formal generation, holistic understanding of the interplay between parts and overall relationships, novel engineering research and techniques, and others. We learned about digital craftsmanship, concise tool selection and deployment, patterning and texture and their remnant traces, and the efficiency and comparative advantages of these computational methods. CNC machines operate along the X, Y, and Z axes. We used them in combination with Rhino Cam to create a tool path, and then drew it using the appropriate tool bit. A pen connected to a CNC machine performs the drawing, with the CNC machine processing the computer-created digital drawing by assigning X,Y,Z coordinates. Because of this mechanism, draw-

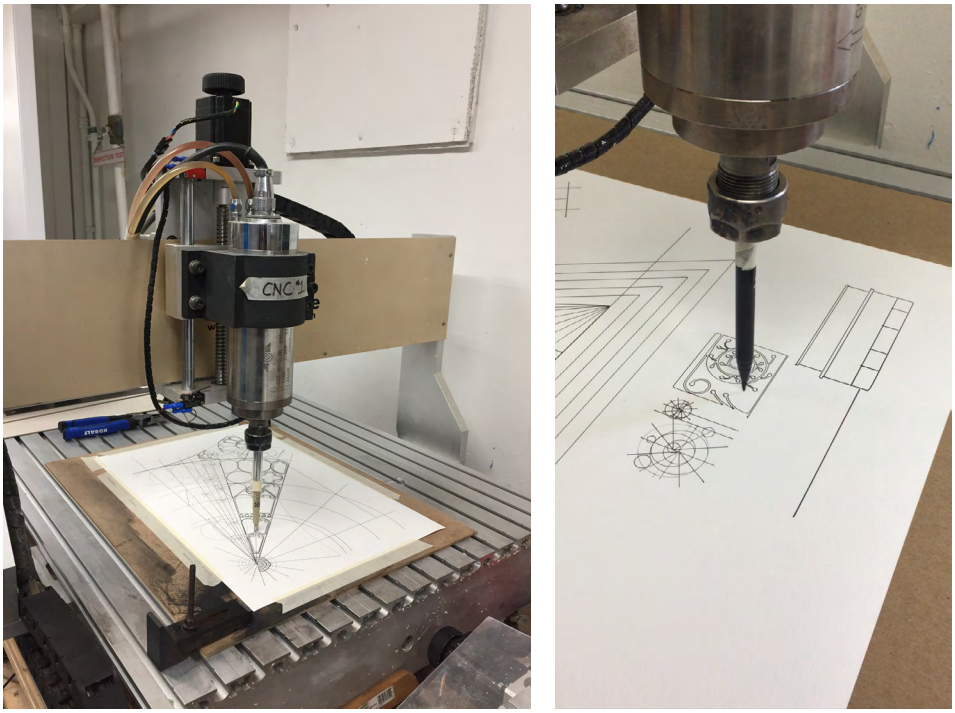

Fig 1. Drawing with CNC machine

ing paths can only be implemented through a change in the code of the X,Y, and Z axis values. This restriction affects the development of architectural ideas. Users need to make the decision regarding how the code will be formed and read. The mechanism also necessitates the process of determining the order of drawing, and the pre-validation and choice of the size of the tools to be employed. The resulting drawing is not simply a machine-made drawing, but an output that incorporates a variety of textures, colors, and strokes depending on the selections made during the process, for example, the choice of the pen. Moreover, depending on the characteristics of the paper, pen, and ink, such as weight, texture, absorption rate, etc., even the same pen can lead to different effects. It is also possible to simulate numerous common methods, such as an ink painting created from an oriental brush. Such simulated drawings retain the quality and excellence achieved from the craftsmanship and architects of the Gothic and the Renaissance styles. We can

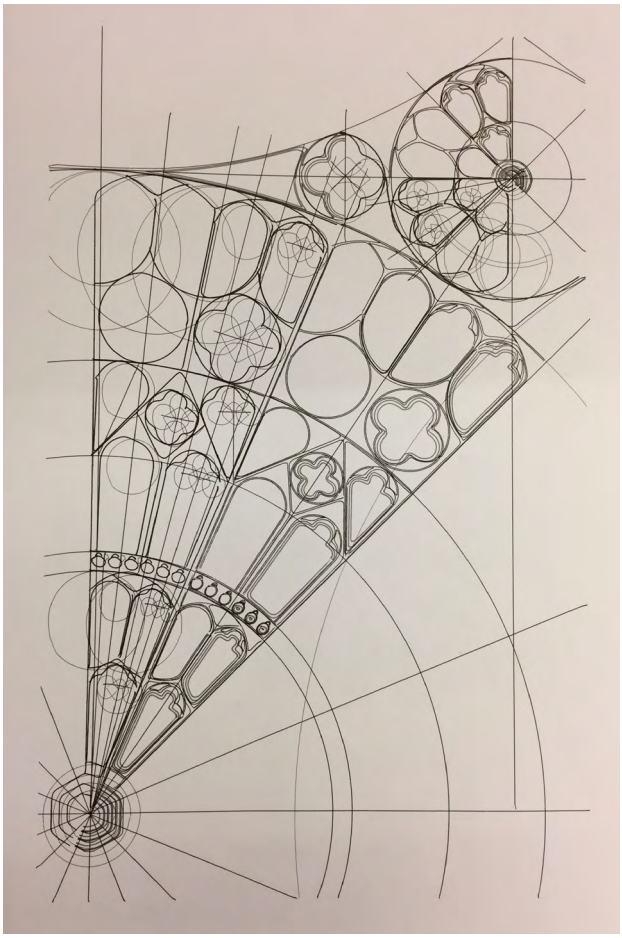

Fig 2. CNC drawing- pigment ink pen
Ceiling of Henry VII Lady Chapel

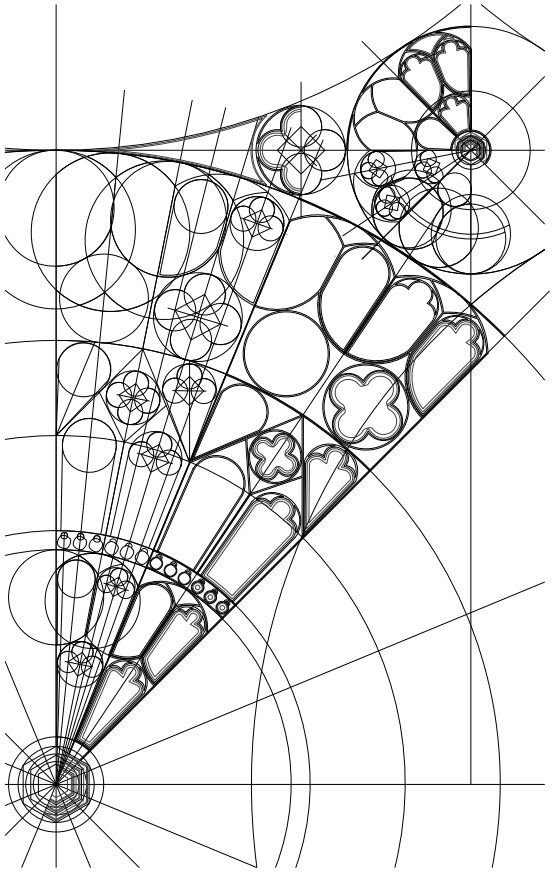

Fig 3. Digital Drawing
Ceiling of Henry VII Lady Chapel

also approach the unique emotional expression that hand-drawings are able to render. Whereas humans are limited by their ability and efficiency, CNC machines are tireless and unaffected from repetition in tasks and at the same time approaching the quality of human craftsmanship.

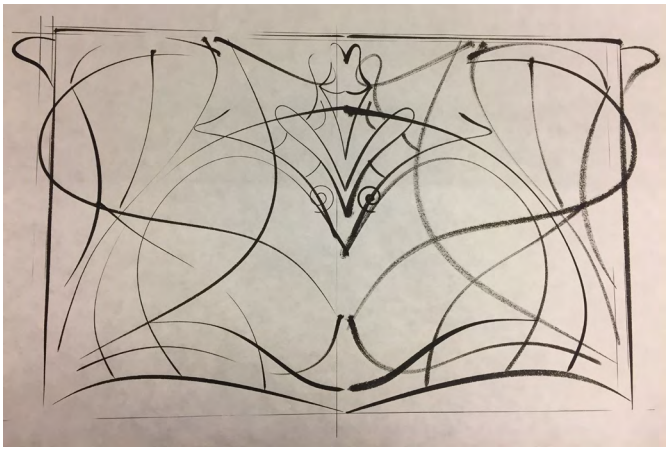

Fig 4. CNC Drawing- brush ink pen
Vitor Guimard railing

Fig 5. CNC Drawing- sharpie pen
Vitor Guimard railing

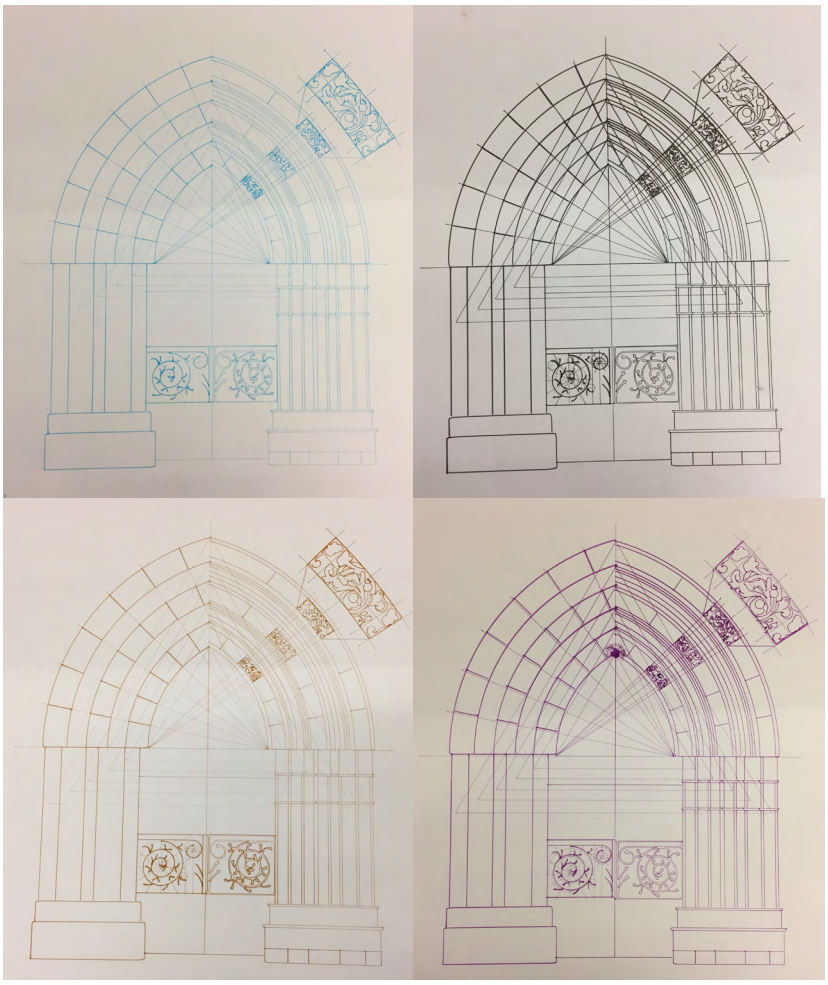

Fig 6. CNC Drawing- brush pen
Lichfield Cathedral
South door

2.2 Further Exploration

Building on the foundation of CNC-developed tool paths, I continued my study and understanding of expression methods using CNC in the subsequent studio work. I grasped how tiling leverages the benefits of a mass-produced fabrication logic and the high accuracy with which simple molds can be reproduced in repetition. It was interesting to note how an aperiodic tiling strategy allows for an infinite array of patterns through careful choice of a strong logic and consideration for the edge condition. The CNC tool path was also crucial in the development of the final physical model. The sophistication of the tool path inspired me to evaluate further the implementation with different bits and tool paths from the same 3D model. The more I understood the CNC machine and the tool path, the more range and expression I was able to express using the technology.

Fig 7. Tiling mold - Wax

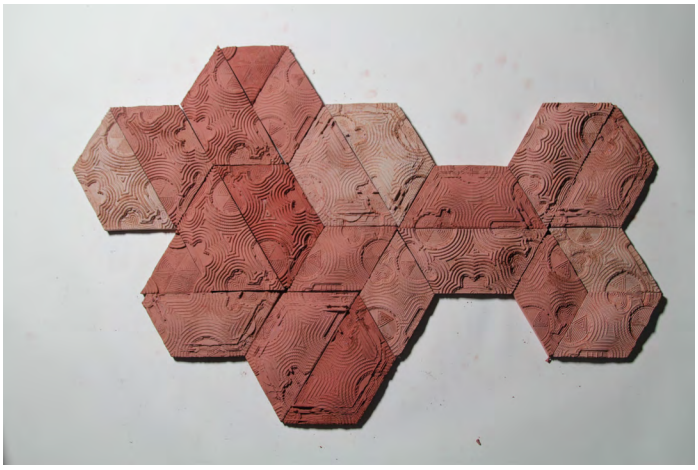

Fig 8. Concrete Tile with color pigment

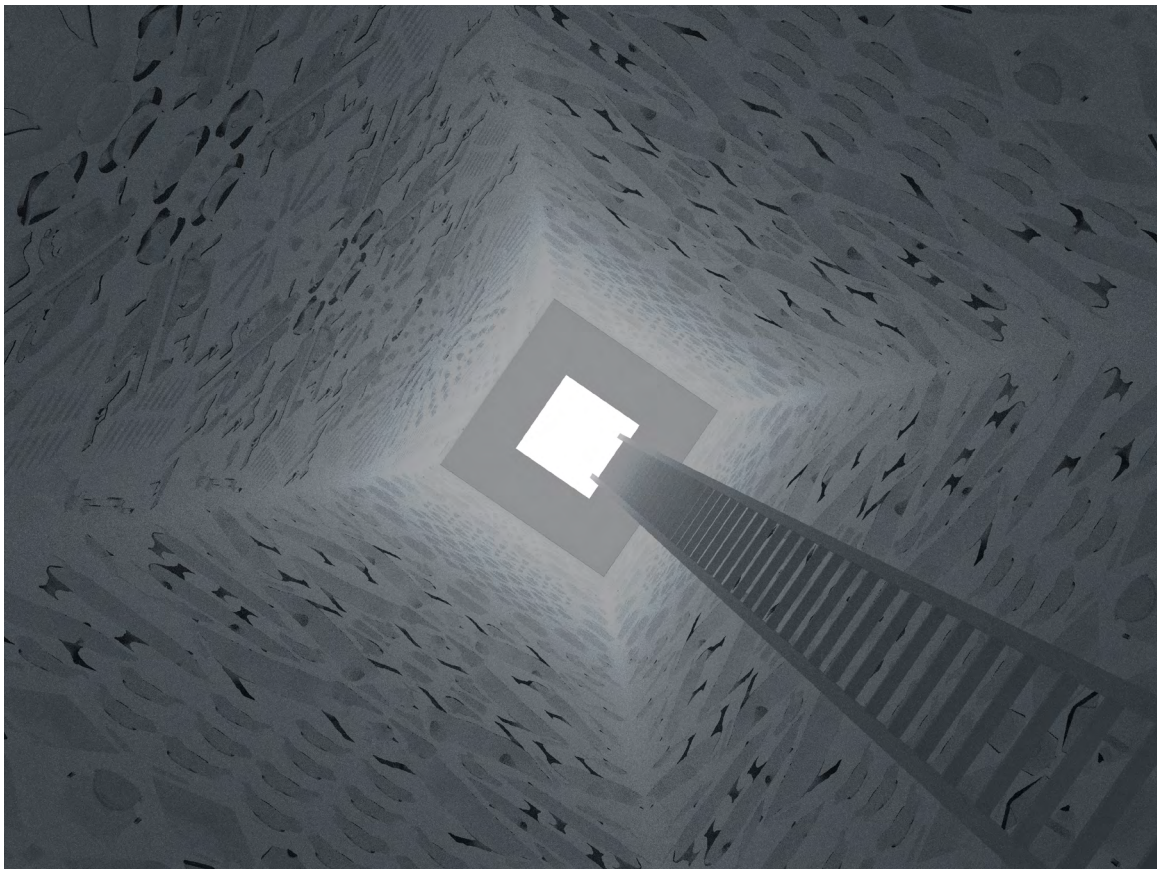

Fig 9. Interior view

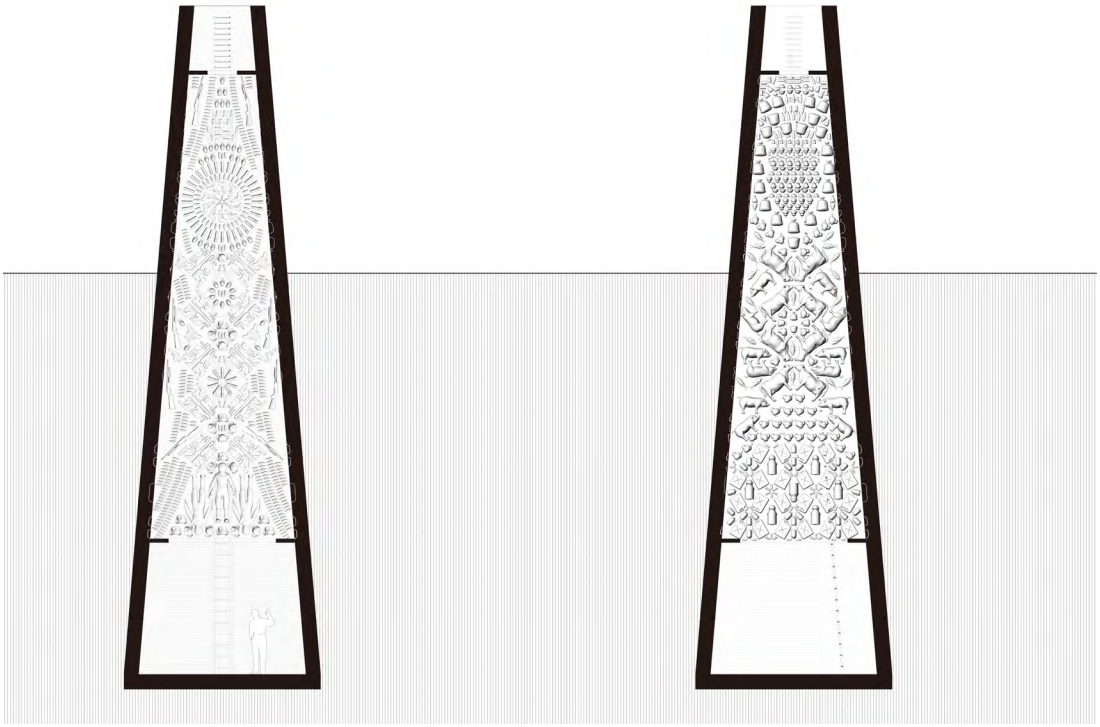

Fig 10. Section

Fig 11. Foam mold

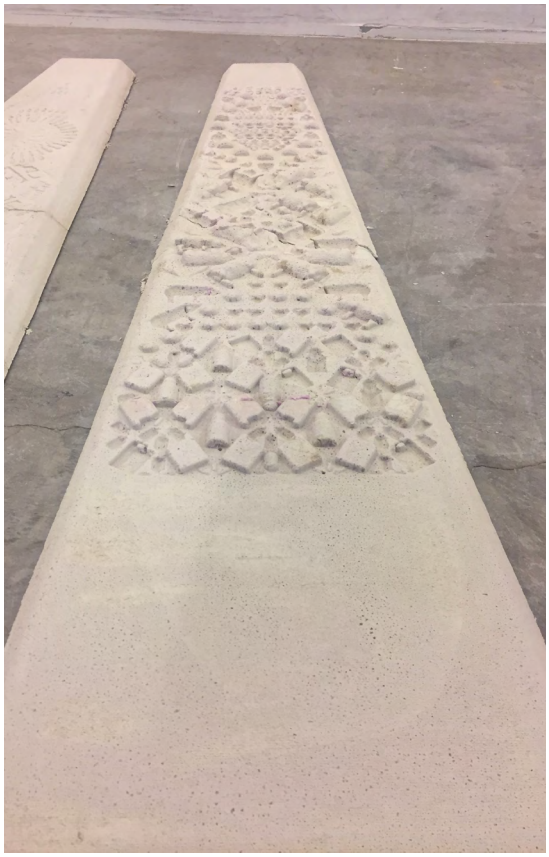

Fig 12. Concrete model

3. Computer Coding

3.1 Python

In the 2018 Summer Semester Design Seminar, instructor Fleet Hower and the class analyzed drawings made using the programming language Python. We made various foams by randomly rotating, mirroring, and scaling up and down two volumes. We were able to see the many possibilities of recombining and subtracting two base volumes, with different values created from each regeneration.

```
import rhinoscriptsyntax as rs
import random

obj1 = rs.GetObject("pick first object",16)
obj2 = rs.GetObject("pick second object",16)

crv1 = rs.GetObject ("pick first curve",4)
crv2 = rs.GetObject ("pick second curve",4)

mid = rs.CurveMidPoint (crv1)

#create first rotation vector

start1 = rs.CurveStartPoint (crv1)
end1 = rs.CurveEndPoint (crv1)
vec1 = rs.VectorCreate (start1,end1)

#create second rotation vector

start2 = rs.CurveStartPoint (crv2)
end2 = rs.CurveEndPoint (crv2)
vec2 = rs.VectorCreate (start2,end2)

for i in range(5) :
   for n in range(5) :
      #rotate first object
      rotated1 = rs.RotateObject(obj1,mid,i*30,vec1,True)
      rotated2 = rs.RotateObject(obj2,mid,n*30,vec2,True)

      #scale of object by random amout
      factor1 = 0.5+random.random()*1
      scale1 = rs.ScaleObject (rotated1,mid,[factor1,factor1,factor1])
      #mirror 2nd object
```

```
mirror2 = rotated2
factor2 = random.random ()
if factor2 < 0.5 :
    mirror2 = rs.MirrorObject(rotated2,start2,end2)

#move first rotated object
rs.MoveObject (scale1,[30+i*30,n*30,0])
rs.MoveObject (mirror2,[30+i*30,n*30,0])
```

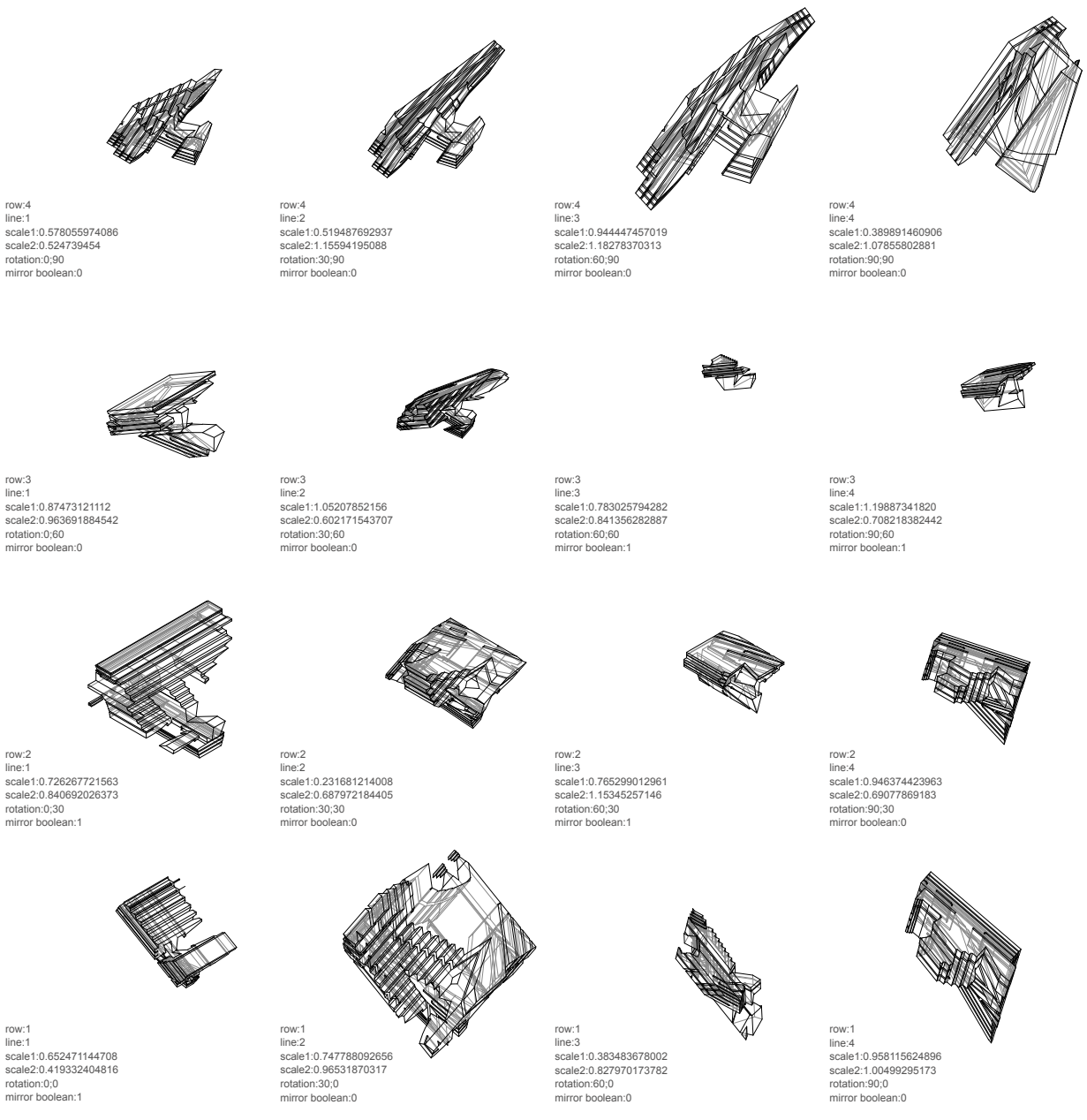

Fig 13. Python drawing - Form generation

3.2 Processing

Through the open-source code generation program named Processing, we were able to draw dots using the mouse pointer. The options and settings that we explored included the size of the canvas, number of dots that will attract or push one another, the thickness and color of the lines formed by the movement of the dots, and other parameters. Upon running the program, the drawing continued to form automatically. The above case studies demonstrate how certain drawings are not possible without the knowledge of the technological instruments that are able to make them. This knowledge includes a sufficient understanding of the programs, the operating principles of the computer and the instruments, and the associated software environment, above and beyond a thorough understanding of **a**rchitectural principles and foundations. Even with the knowledge, the skill and expertise involved in selecting and controlling various available options and parameters (and the restrictions and constraints therein), along with the processing methods and computer randomness can result in drawings that have an element of chance that would be difficult to obtain from hand drawings.

```
ArrayList pts = new ArrayList();
ArrayList vels = new ArrayList() ;

void setup() {
  background(255, 255, 255);
  size(3000, 3000);
  for (int i=0; i<2000; i++) {
    PVector pos = new PVector(random(1450,1550), random(1450,1550));
    pts.add(pos);
    PVector vel = new PVector(random(-1,1), random(-1,1));
    vel.setMag(1);
    vels.add(vel);
  }
}

void draw() {
  if(frameCount%100==0){
    saveFrame("####.png");
    println(frameCount);
  }
  if(frameCount == 5){
   //background(255);
  }

  //background(255, 255, 255);
```

```
borders();
for (int i=0; i<pts.size(); i++) {
  PVector p = (PVector) pts.get(i);
  PVector v = (PVector) vels.get(i);
  PVector mouseMove = p.copy().sub(mouseX, mouseY);
  float dist = dist(p.x, p.y, mouseX, mouseY);
  mouseMove.setMag(1);
  if (dist>0){
    mouseMove.setMag(1/dist);
  }
  mouseMove.mult(-10);
  if(mouseMove.mag()>1){
    mouseMove.setMag(1);
  }
  //v.add(mouseMove);
  stroke(0,0,0);
  for (int j=0; j<pts.size(); j++) {
    if(i!=j){
      PVector other = (PVector) pts.get(j);
      float otherDist = dist(p.x,p.y,other.x,other.y);
      float limit = 10;
      if (otherDist<limit){
        stroke((255/limit)*otherDist);
        strokeWeight(.05);
        //line(p.x,p.y,other.x,other.y);
        PVector othervel = (PVector) vels.get(j);
        PVector align = othervel.copy();
        align.setMag(1);
        align.mult(1/(otherDist*otherDist));
        align.mult(.7);
        align.limit(.7);
        v.add(align);
        PVector cohere= other.copy().sub(p.copy());
        cohere.setMag(1);
        cohere.mult(1/(otherDist*otherDist));
        cohere.mult(.3);
        cohere.limit(.3);
        v.add(cohere);
        PVector avoid= p.copy().sub(other.copy());
        avoid.setMag(1);
        avoid.mult(1/(otherDist*otherDist));
        avoid.mult(.9);
        avoid.limit(.9);
        v.add(avoid);
      }
    }
  }
  v.setMag(1);
  p.add(v);
```

```
    stroke(0);
    //fill(0);
    strokeWeight(.08);
    ellipse(p.x,p.y,.08,.08);
  }
}

void borders() {
  for (int i=0; i<pts.size(); i++) {
    PVector p = (PVector) pts.get(i);
    if (p.x<0) {
      p.x=width;
    }
    if (p.x>width) {
      p.x=0;
    }
    if (p.y<0) {
      p.y=height;
    }
    if (p.y>height) {
      p.y=0;
    }
  }
}
```

Fig 14. Processing Drawing-1

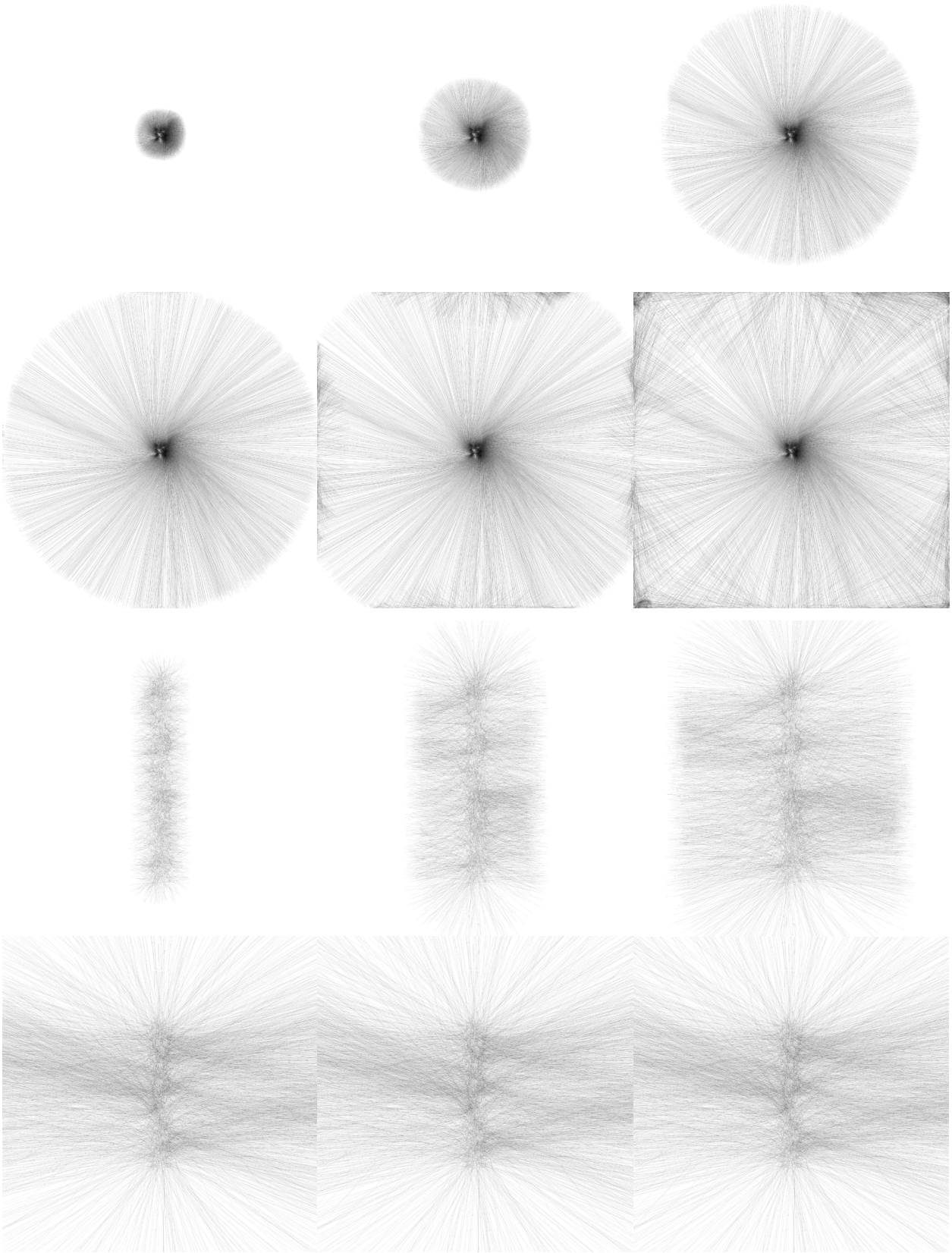

Fig 15. Processing Drawing-2, 3

4. Computer Drawing

The last research area was the 2018 Fall Semester Seminar Drawing the Invisible with instructors Alejandro Beals and Loreto Lyon. This seminar focused on the conversion of written text to 2D drawing. Words are effective in evoking and describing ambience, feelings, emotions, multi-sensory experiences (beyond the visual, such as temperature, sound, smell, and taste) and complex concepts such as aging and the passage of time. In this seminar, we learned how to depict and communicate such themes and ideas, where images sometimes eclipse words and become an autonomous narrative piece. Using drawings, we explored the role of architecture in literature, for instance, architectural representation of objects as plot device for conveying spatial and atmospheric qualities. As an exercise, we edited some text in a book that expresses these spatial ideas and themes. We then worked to express the edited text through drawings. In the process, a black-and-white hatch and tone was used to create spatial depth and atmosphere. The purpose of this exercise was to acknowledge the potential and efficiency of expressing spatiality and other ideas in written text with simple black-and-white options. It was exciting to practice this technique of recreating literature and mapping it onto space through the use of computer drawings.

I have an exceptional, I believe fairly prodigious even, memory of all the places I have slept in, with the exception of those from my earliest childhood –

the position of the doors and windows, the arrangement of the furniture – for me to feel, more precisely still, the almost physical sensation of being once again in bed in that room.

I have several times tried to think of an apartment in which there would be a useless room, absolutely and intentionally useless.

I thought of the dreams I had had on this very subject, discovering a room I didn't know about in my own apartment.

How to expel functions, rhythms, habits, how to expel necessity?

Bit by bit, as if by chance, without thinking,

the ground began to resemble, very vaguely,

mouldings and ceiling with an extreme nonchalance even,

a slight declivity that was oblique to start with

The wall is no longer what delimits and defines the place where I live, that which separates it from the other places

I no longer know whether you were indoors or out.

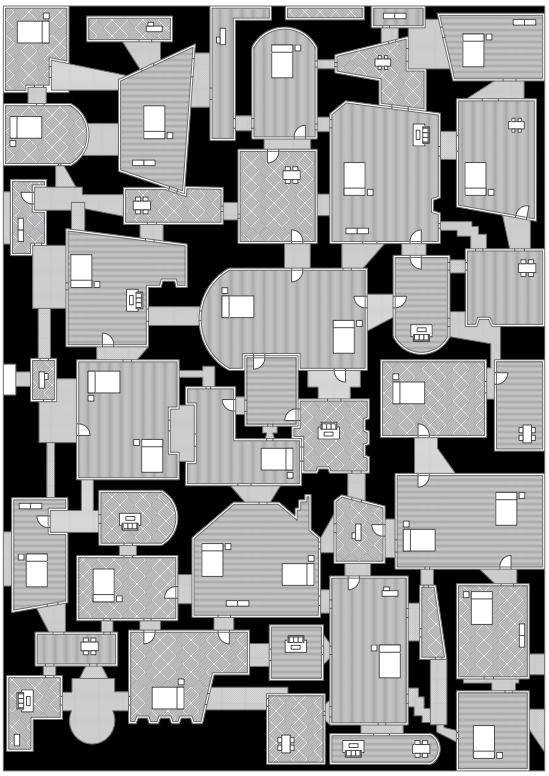

Fig 16. Text edited from "Species of Spaces" Georges Perec
Computer drawing from edited text

High in the empty streets of the harbor district they are as densely and loosely clustered as butterflies on a hot flower bed.

Every step stirs a song, a quarrel, a flapping of wet linen, a rattling of boards, a baby's bawling, a clatter of buckets.

The high-breasted nymphs, the snake-ringed Medusa's heads over their weather-beaten doorframes have only now become unambiguously the signs of a professional guild.

The gray houses of the Boulevard de Longchamps, the barred windows of the Cours Puget, and the trees of the Allée de Meilhan give nothing away to the traveler if chance does not lead him to the Passage de Lorette,

the narrow yard of the city,

The street . . . the only valid field of experience.

Fig 17. Text edited from "Reflection" Walter Benjamin
Computer drawing from edited text

Walter Gilman

was in the changeless, legend-haunted city of Arkham, with its clustering gambrel roofs that sway and sag over attics where witches hid from the King's men in the dark, olden days of the Province.

Gilman's room was of good size but queerly irregular shape; the north wall slanting perceptibly inward from the outer to the inner end, while the low ceiling slanted gently downward in the same direction.

In March 1931, a gale wrecked the roof and great chimney of the vacant Witch House, so that a chaos of crumbling bricks, blackened, moss-grown shingles, and rotting planks and timbers crashed down into the loft and broke through the floor beneath.

the slanting wall of Gilman's room was torn out, the once sealed triangular space between that partition and the house's north wall was found

the space which must have existed between the slanting wall and the straight outer wall on the house's north side,

He was in a crude, windowless little space with rough beams and planks rising to a peak just above his head, and with a curious slanting floor underfoot. Propped level on that floor were low cases full of books of every degree of antiquity and disintegration, and in the centre were a table and bench, both apparently fastened in place.

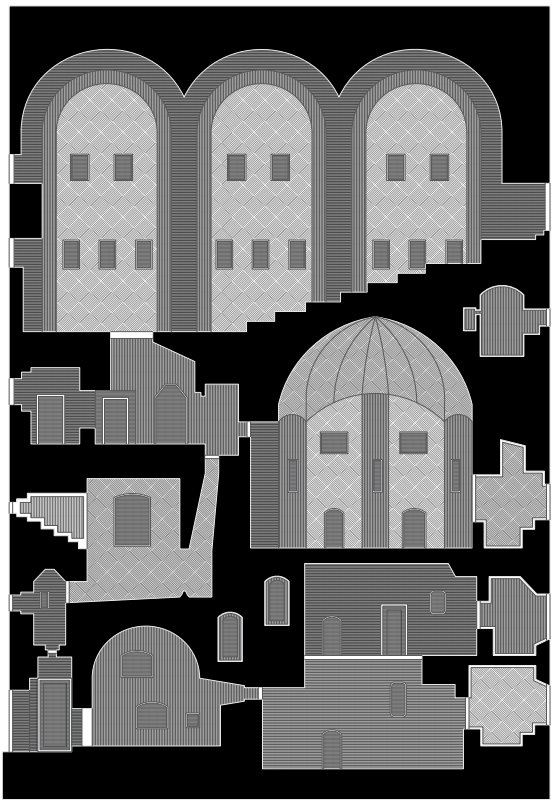

Fig 18. Text edited from "The dreams in the Witch House" H.P Lovecraft
Computer drawing from edited text

Fig 19. Paper model from text and drawing above (Fig 18)

5. Conclusion

Through the research of Territory of Investigation and my exercises and practice with CNC machines, computer coding, computer drawings, and its associated techniques and skills, I believe my architectural and creative potential expanded by a dramatic amount. The range of expressible possibilities opened my mind to the potential of not just technology in architecture, but that of architecture itself. I endeavored to and will continue to strive to build a thorough grasp of computer instruments and their underlying logic, to develop my capability as a technology-proficient architect for the purpose of enhancing my idea development process and the efficiency with which I can perform the architect's purpose, transferring possibilities and imagination onto paper.

6. Documentation

6.1 Studio

2018 Summer Studio, Urbanism, Instructor David Moon, Nahyun Hwang

Group Work : Olga Tarasova, Zeynep Kuheylan, Chen Qin, Ching-Lun Chen

Fig 20. Analytical Drawing

Fig 21. Section Perspective

2018 Summer Studio, Ecology, Instructor Tei Carpenter, Jesse LeCavalier

Group Work : Ching-Lun Chen, Chen Shen, Quinzhqu Yan

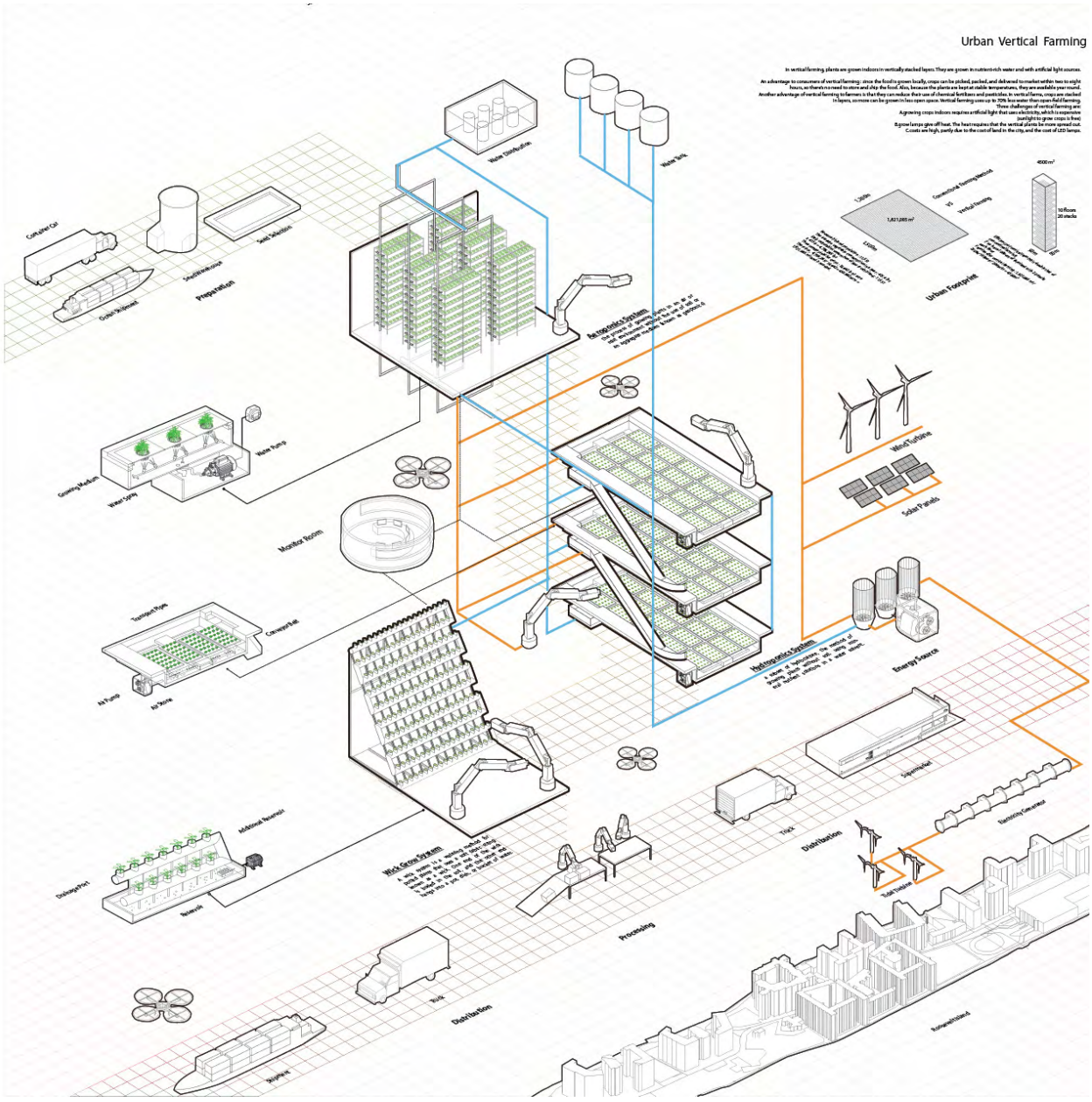

Fig 22. System Drawing

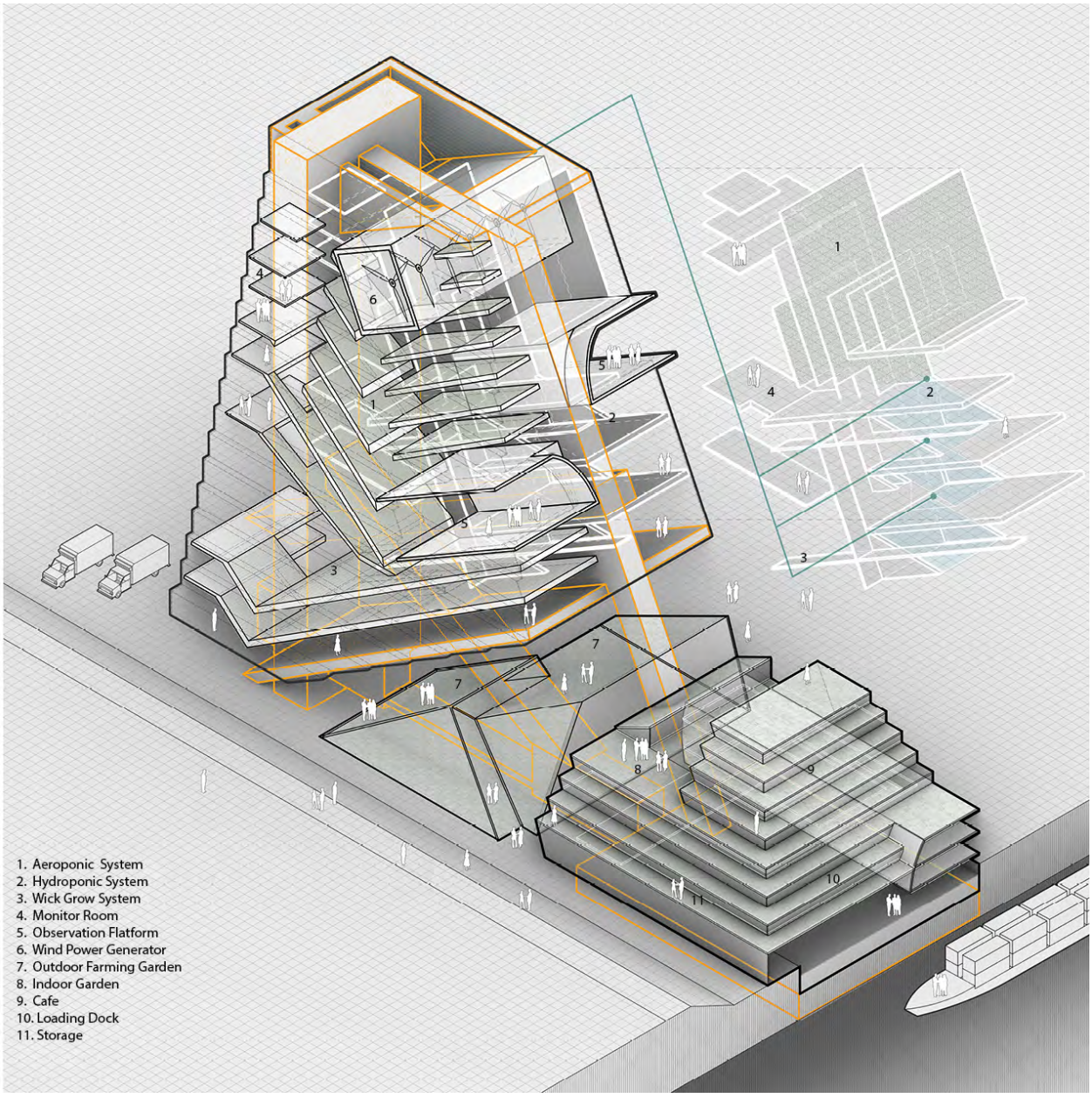

Fig 23. Ghost Drawin

2018 Summer Studio, Discourse, Instructor Michael Young, Kutan Ayata

Group Work : Chen Qin, Jingning Ji

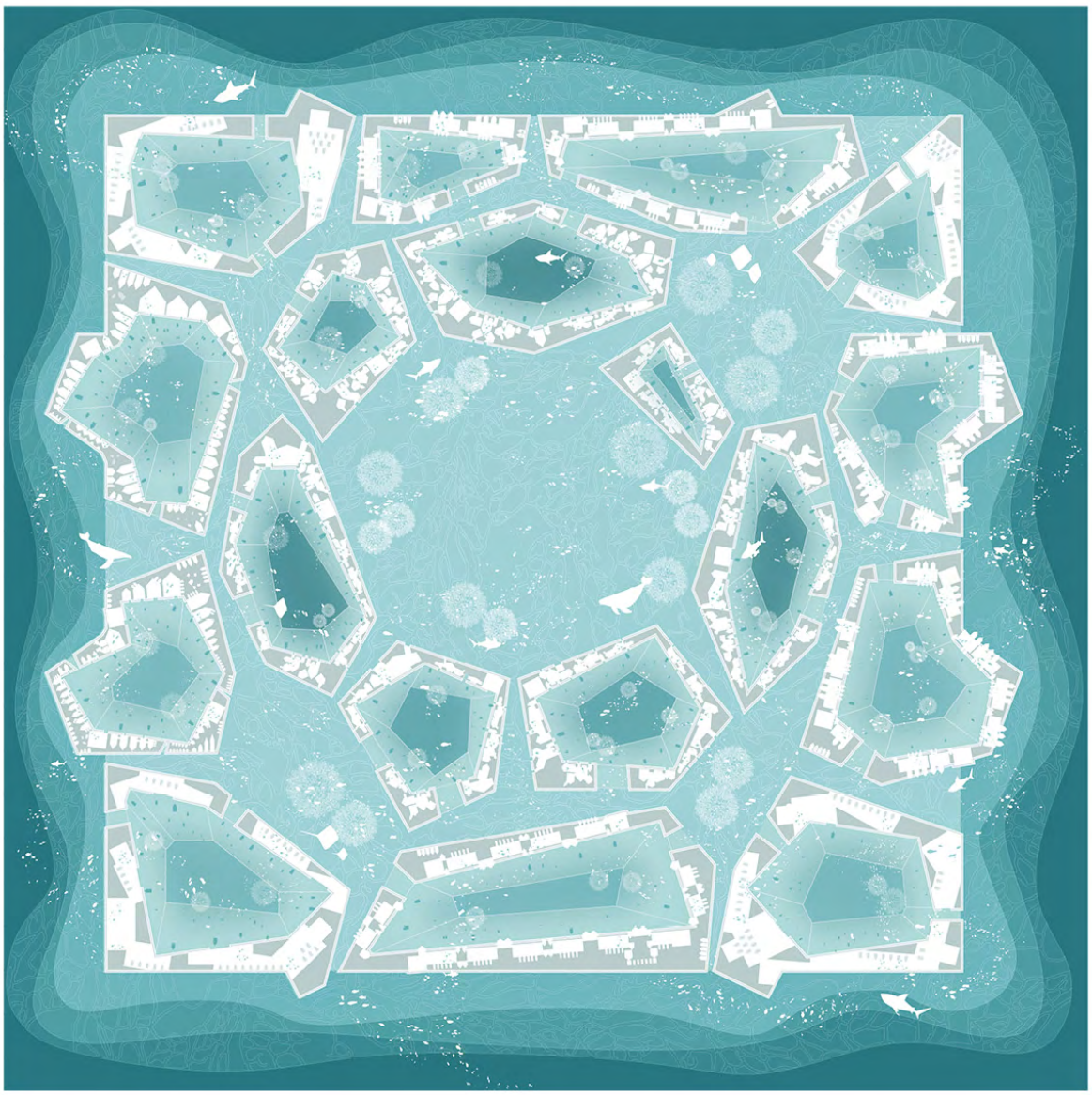

Fig 24. Plan

Fig 25. Section

6.2 Elective

2018 Fall Semester, Crawling Skin: Kinetic Facade System, Instructor Martin Miller

Group Work : Xiatong Wang

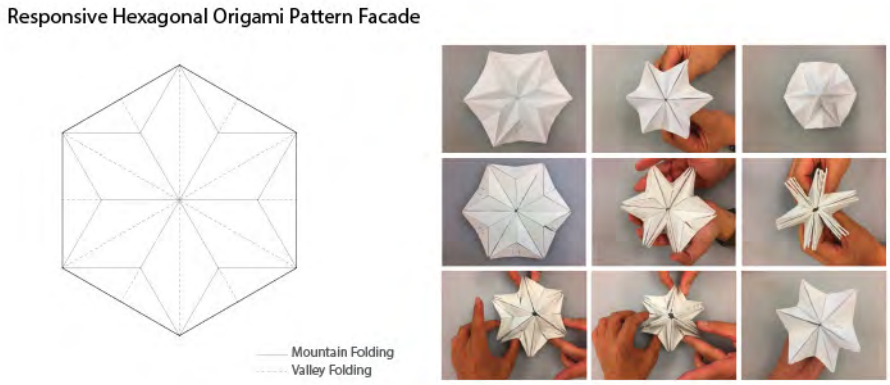

Fig 26. System Drawing

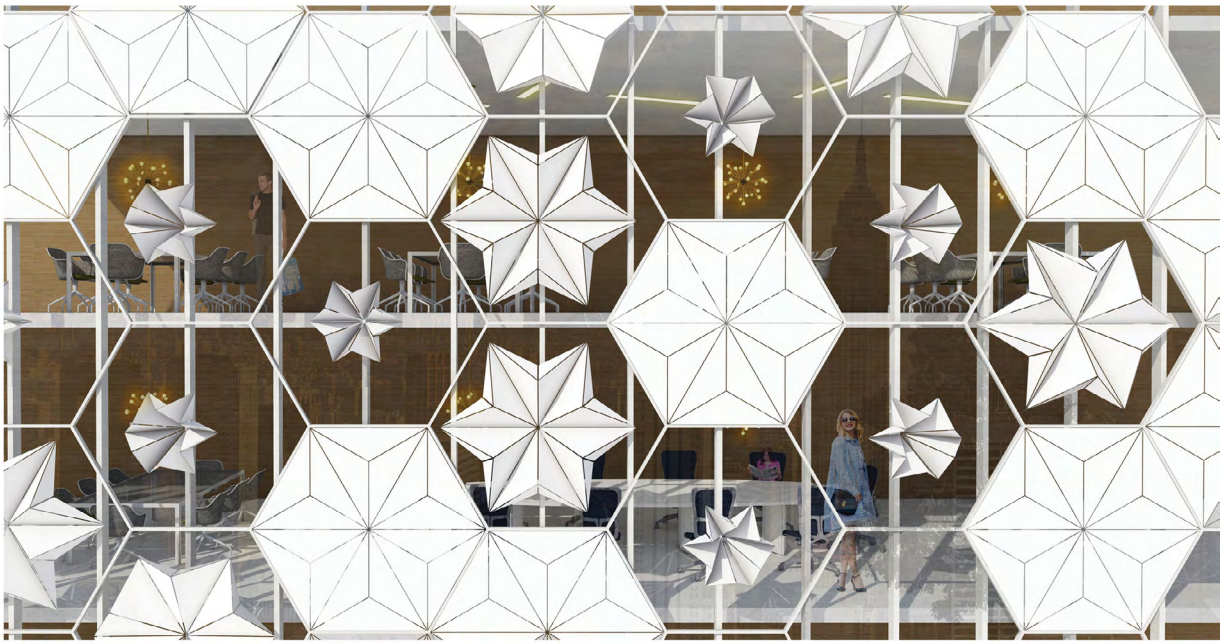

Fig 27. Perspective

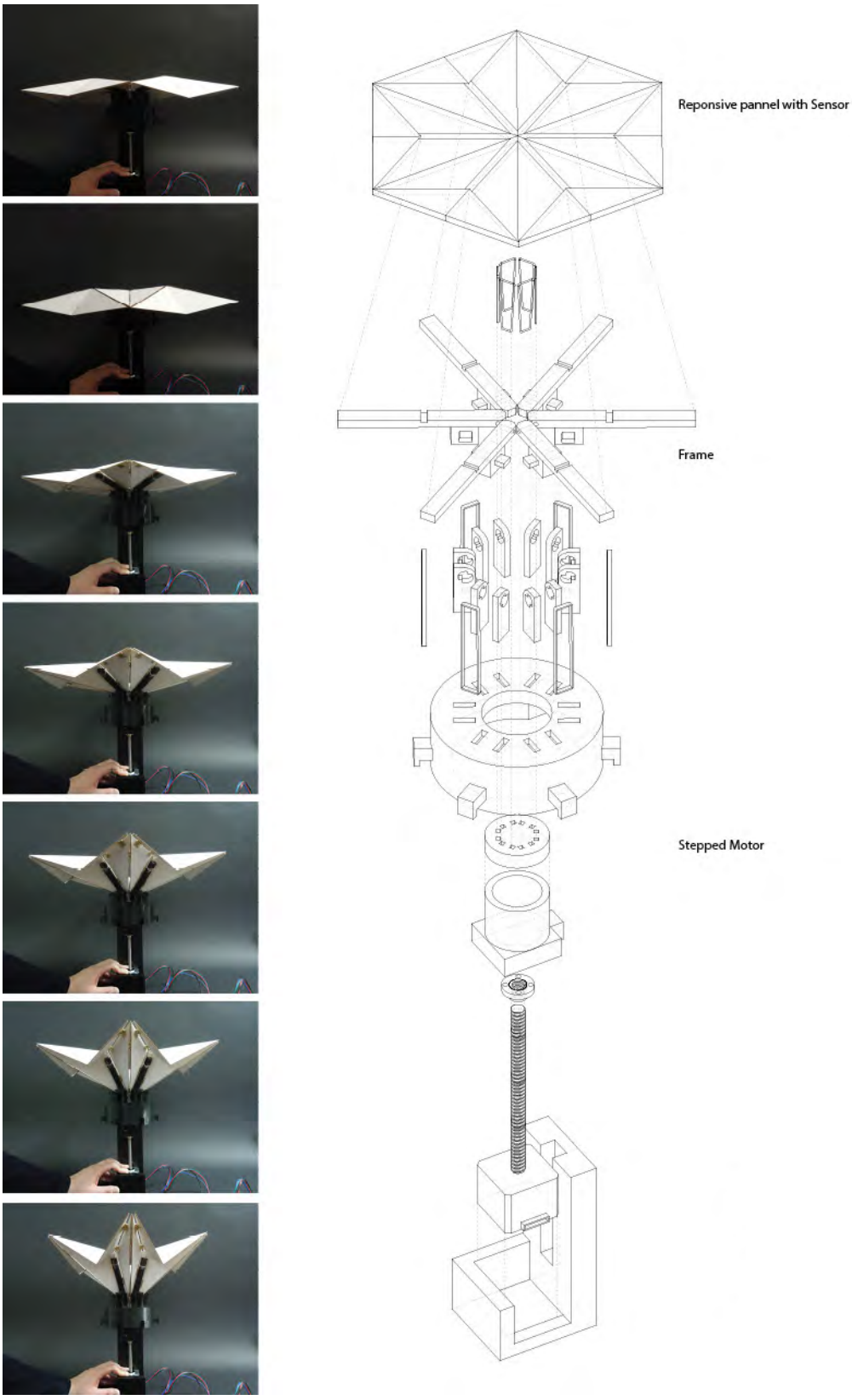

Fig 28. Model Photo and Mechanism Drawing

2019 Spring Semester, In Pursuit of Great Form Column Typologies,

Instructor Umberto Bellardi Ricci

Group Work : Chen Qin, Jingning Ji

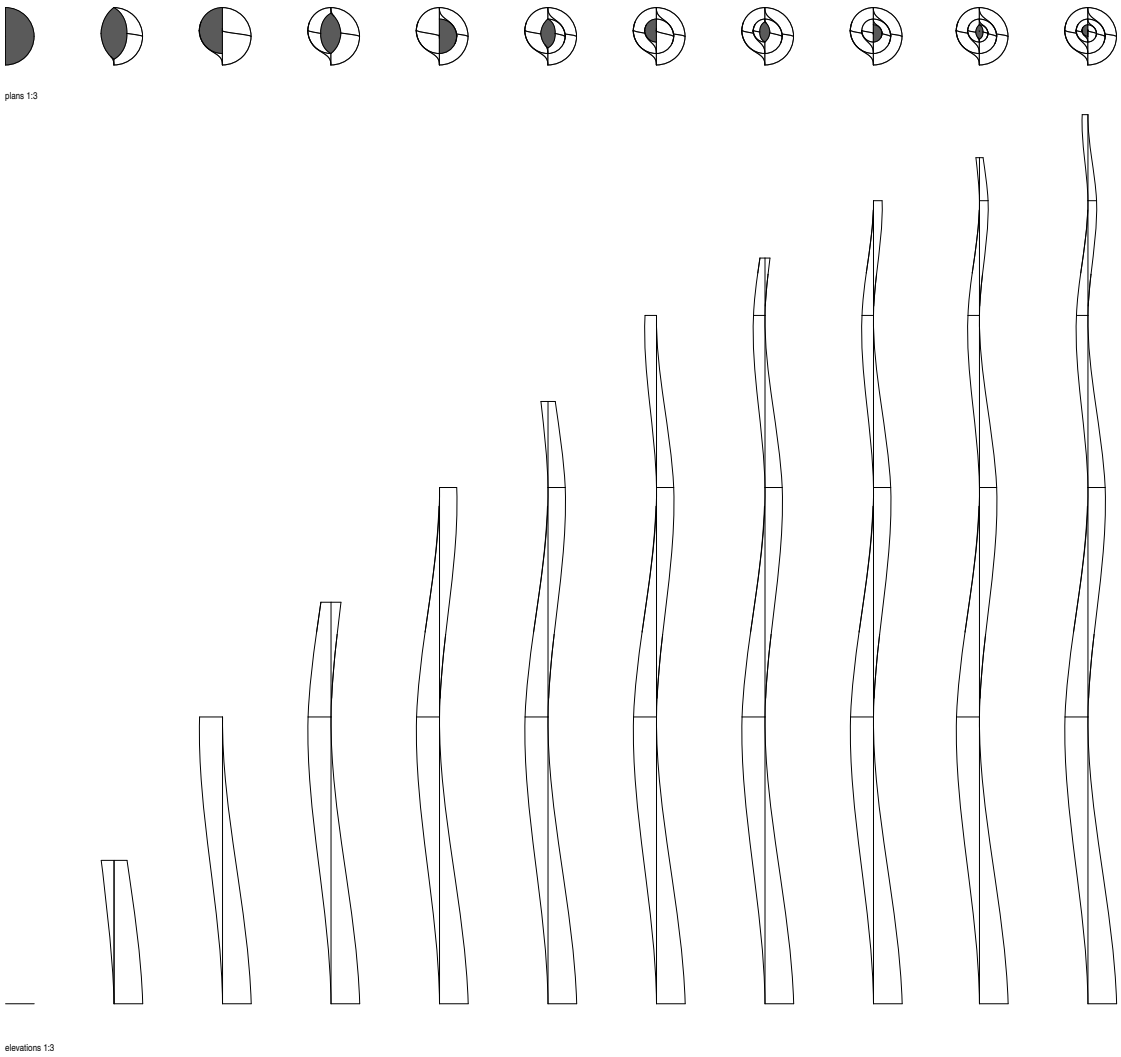

Fig 29. Plan and Elevation

Fig 30. Model Photo

2019 Spring Semester, Drawing as Parallel Practice, Instructor Dasha Khapalova

Fig 31. Hand Drawing

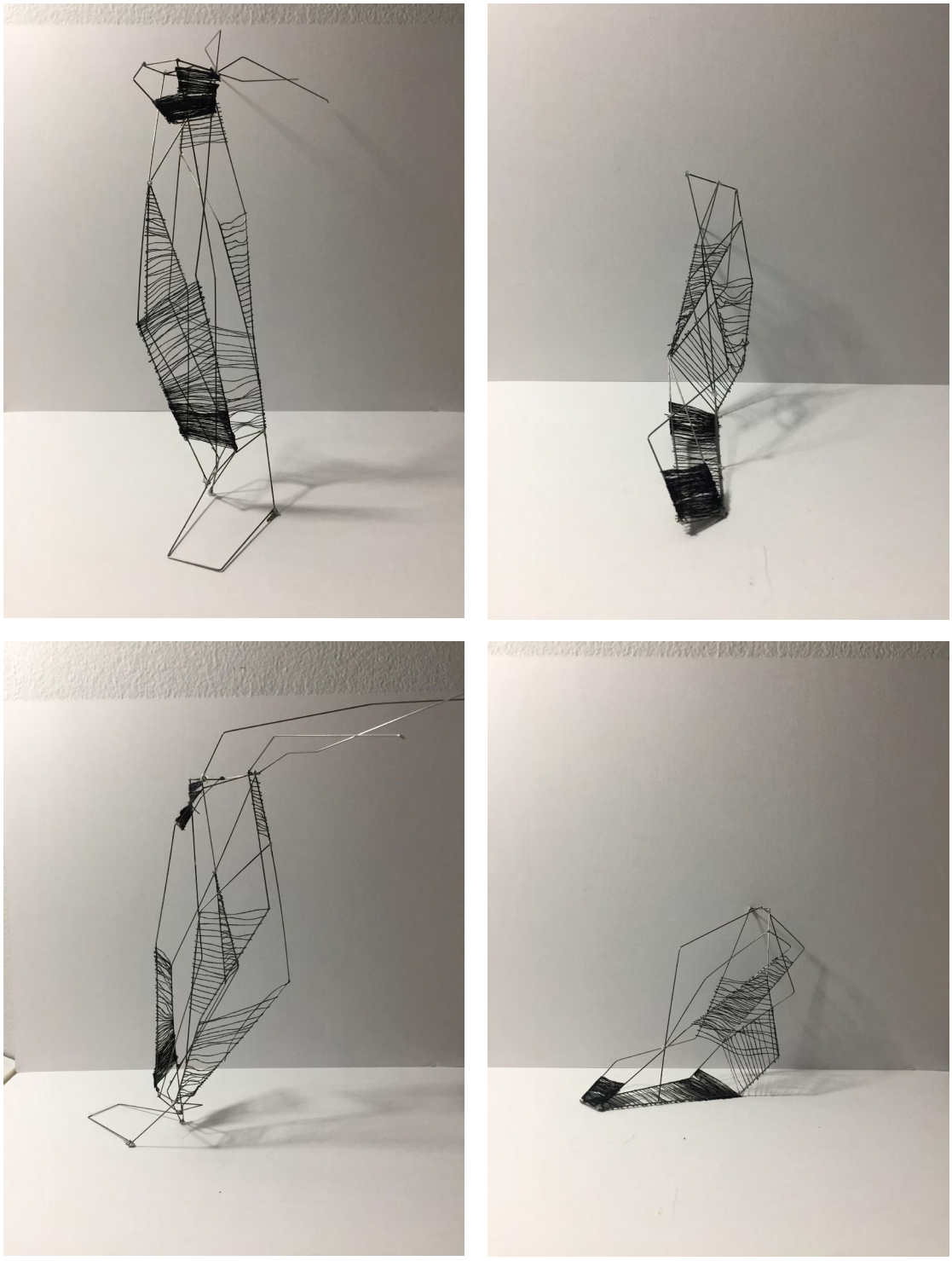

Fig 32. Model Photo

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